

It's about time: A comparison of Canadian and American time–activity patterns[†]

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This study compares two North American time–activity data bases: the National Human Activity Pattern Survey (NHAPS) of 9386 interviewees in 1992–1994 in the continental USA with the Canadian Human Activity Pattern Survey (CHAPS) of 2381 interviewees in 1996–1997 in four major Canadian cities. Identical surveys and methodology were used to collect this data: random sample telephone selection within the identified telephone exchanges, computer-assisted telephone interviews, overselection of children and weekends in the 24-h recall diary and the same interviewers. Very similar response rates were obtained: 63% (NHAPS) and 64.5% (CHAPS). Results of comparisons by age within major activity and location groups suggest activity and location patterns are very similar (most differences being less than 1% or 14 min in a 24-h day) with the exception of seasonal differences. Canadians spend less time outdoors in winter and less time indoors in summer than their U.S. counterparts. When exposure assessments use time of year or outdoor/indoor exposure gradients, these differences may result in significant differences in exposure assessments. Otherwise, the 24-h time activity patterns of North Americans are remarkably similar and use of the combined data set for some exposure assessments may be feasible.

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Introduction

Time–activity studies have become an integral part of risk management for assessing a large number of environmental exposures and are particularly appropriate for incorporation in mathematical prediction models of exposure assessment (Duan, 1982; Johnson et al., 1996; Sexton and Ryan, 1998). While several approaches to recording time–activity data have been used, ranging from self-administered recall to directly supervised observation, the 24-h recall diary has found general acceptance after its application by the California Air Resources Board for exposure assessment (Wiley et al., 1991). Using a similar 24-h recall diary the United States' Environmental Protection Agency undertook a random sample telephone survey of the time and activity patterns throughout the continental USA in 1992 to 1994, the National Human Activity Pattern Survey (NHAPS)

(Klepeis et al., 2001). This study compares the NHAPS results to a survey using the same methodology in a smaller random sample within four Canadian cities in 1996–1997, the Canadian Human Activity Pattern Survey (CHAPS) (Leech et al., 1996). The comparison was made both for the insight it might provide to exposure similarities and differences in the two countries and to see if the larger U.S. data set, or a combination of the two data sets, would be appropriate for exposure assessment models for Canadians.

Methodology

Detailed survey methodology of the two surveys has been previously published (Klepeis et al., 2001; Leech et al., 1996; Nelson et al., 1996; Tsang and Klepeis 1996).

Essentially, a random sample telephone survey was administered by Computer Assisted Telephone Interview (CATI) by the University of Maryland Survey Research Centre in both studies. First, from selected location maps, telephone company exchanges were identified. Telephone numbers were then selected at random using a two-stage Waksberg–Mitofsky random digit dialing sample design (Waksberg 1978). Each day of the week was sampled

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Table 1. A comparison of sample response rates.

	CHAPS		NHAPS	
	Number	% Response	Number	% Response
<i>Sample</i>				
Phone Numbers	7,339		26,263	
Nonhouseholds	3,379		11,076	
Status unknown	267		279	
Households	3,693	100	14,908	100
<i>Interviews</i>				
Completed	2,381	65	9,386	63
Refusals	565	15	2,944	20
Noncontact	469	13	1,870	12
Other ^a	278	8	708	5

^aCommunication difficulties were experienced, i.e., deafness, linguistic differences, comprehension problems.

with approximately equal frequency; weekend days were oversampled.

The target population was all persons in households with telephones within the telephone exchanges selected. Subjects were chosen using the "next birthday" method. That is, the person with the next birthday was asked to provide information. For respondents under the age of 10, the adult in the household most knowledgeable about the child's activities was asked to complete a proxy interview. For youths aged 10 to 17, the youth answered the time diary questionnaire but an adult provided the sociodemographic information and answered general questions about the household. Children and youth were oversampled at the time of subject selection because of the

presumption that they may be more susceptible to environmental hazards.

Subjects were asked to sequentially list all activities they could recall for the 24-h period beginning at midnight on the day prior to the interview. The interviewer sought details on the location, the start and stop time of each activity and whether subjects were exposed to tobacco smoke during the activity. Data was entered directly during the interview using preset codes for activity and location. If the subject did indicate a change in activity over a prolonged period of time, the interviewer probed for any possible oversights. The computer aided the interviewer by chronologically ordering the day's activities even if the subject tended to skip about. In addition to the 24-h recall diary, two supplemental questionnaires were asked. The first was a set of questions regarding a variety of sociodemographic, family and housing characteristics (such as type of housing, heating and air-conditioning). The second was a supplemental questionnaire in which all subjects were randomized to determine specific exposures either to airborne pollutants or to water-based pollutants.

Survey Differences

The Canadian survey differed from the U.S. survey in that the phone exchanges within which randomization occurred were geographically limited to four cities and their suburbs for financial and linguistic reasons. The four Canadian cities were Vancouver, Edmonton, Toronto and Saint John, New Brunswick. In the 1997 census survey, these cities make up approximately 25% of the total Canadian population. There

Table 2. Distribution of CHAPS and NHAPS respondents by selected background factors.

Factor	CHAPS		NHAPS	
	Sample size	%	Sample size	%
Male	1160	48.72	4294	45.75
Female	1219	51.20	5088	54.21
<5 years	143	6.01	499	5.32
5 to 17 years	412	17.30	1292	13.77
18 to 64 years	1499	62.96	6059	64.55
>64 years	248	10.42	1349	14.37
<i>Among respondents >18 years of age</i>				
Postgraduate Education	148	6.22	924	9.84
College/some college	695	29.19	3048	32.47
High school or less	919	38.60	3446	36.71
Full-time employed	939	39.44	4096	43.64
Current smoker	473	19.87	1770	18.86

For NHAPS: There were 9386 total respondents; 187 (2%) of the respondents did not report an age. Among those over 18: for 1968 (21%) of the respondents no education-level data were recorded; 1844 (20%) of the respondents did not report their employment status; 1045 (11%) of the respondents did not report if they were current smokers. For CHAPS: There were 2381 total respondents; 79 (3%) of the respondents did not report an age. Among those over 18: for 589 (25%) of the respondents no educational-level data were recorded; 614 (26%) of the respondents did not report their employment status; 294 (12%) of the respondents did not report if they were current smokers.

are no rural respondents in the Canadian survey. The University of Maryland Survey Research Center was also used in the Canadian survey in order to have the same interviewers, methodology and questionnaires as developed for the NHAPS survey. The NHAPS study ran from September 1992 to September 1994. The CHAPS study ran from November 1996 to August 1997. Only minor questionnaire variations were required to adapt to the Canadian milieu. For example, questions were altered regarding zip code/postal code and terminology for educational levels achieved.

Method of Analysis

The overall results within Canada and U.S. data were weighted by the population density within a telephone exchange, by the number of residential telephone lines into the house, and by the probability of being a child or adult respondent. The regional comparisons are reported unweighted by population.

Because of the large sample size the comparisons of means by *t*-test between Canadian and U.S. results might be statistically significant but not necessarily important to an exposure assessment of interest. Results are mainly reported as means with confidence intervals so that the reader may assess for themselves the strength of any statistical differences observed. To put results in perspective, a 1% difference in a 24-h day represents about 14 min.

Comparisons

The initial overall comparisons are made between all respondents in each country grouped in 10 major locations, i.e., indoor at home, outdoor at home, school/public building, indoors — other, bar/restaurant, outdoors — other, in vehicles, near vehicles outside, office/factory, mall/store. A subset comparison was made between Toronto and Chicago, two large cities from either study at a similar latitude by one of the Great Lakes. Seasonal comparisons were made by age group.

Results

In Table 1 the sample response rates are compared between NHAPS and CHAPS. From a sampling frame of 26,263 phone numbers NHAPS identified 14,908 household sampling units or 57%; in CHAPS from a sample of 7339 phone numbers 3693 households were identified or 50%. Completed interviews in NHAPS were 63% of eligible households and in CHAPS a very similar rate of 64.5% was achieved. (This is also a similar response rate to the 61% adult sample in the earlier California Activity Pattern (CAP) Survey.) The Canadian refusal rate was slightly lower but communication difficulties slightly higher (Klepeis et al., 2001; Leech et al., 1996).

In Table 2 the two populations' respondents are compared by selected background factors. Nineteen percent of NHAPS respondents and 23% of CHAPS respondents interviewed were under 18. NHAPS had a higher percentage in the over 65 age group than CHAPS (14% vs. 10%).

Table 3. Time spent by location.

Location	Canada	U.S.	<i>p</i>
<i>A. Percent time spent in major locations (with 95% CI), all respondents</i>			
	<i>n</i> =2381	<i>n</i> =9386	
Indoor at home	65.94 (±0.83)	64.97 (±0.42)	0.0423
Outdoor at home	1.41 (±0.18)	2.50 (±0.13)	<0.0001
School/public building	4.21 (±0.40)	3.87 (±0.20)	0.1353
Indoors — other	7.95 (±0.59)	8.39 (±0.30)	0.1968
Bar/Restaurant	1.79 (±0.23)	1.91 (±0.12)	0.3622
Outdoors — other	4.60 (±0.41)	4.23 (±0.20)	0.1054
In vehicles	5.33 (±0.28)	5.74 (±0.12)	0.013
Near vehicles — outside	0.04 (±0.02)	0.19 (±0.04)	0.0002
Office/Factory	5.99 (±0.52)	5.90 (±0.27)	0.7634
Mall/Store	2.73 (±0.27)	2.30 (±0.13)	0.0033
<i>B. Time spent in major locations, age >17</i>			
	<i>n</i> =1747	<i>n</i> =7384	
Indoor at home	64.30 (±0.96)	64.40 (±0.48)	0.8619
Outdoor at home	1.16 (±0.20)	2.27 (±0.15)	<0.0001
School/Public building	2.96 (±0.40)	2.38 (±0.18)	0.0065
Indoors — other	8.14 (±0.68)	8.35 (±0.34)	0.5779
Bar/Restaurant	2.12 (±0.29)	2.22 (±0.14)	0.5532
Outdoors — other	4.30 (±0.47)	4.15 (±0.23)	0.5947
In vehicles	6.01 (±0.36)	6.16 (±0.17)	0.4456
Near vehicles — outside	0.05 (±0.003)	0.22 (±0.05)	0.0012
Office/Factory	7.83 (±0.67)	7.26 (±0.33)	0.1439
Mall/Store	3.13 (±0.35)	2.57 (±0.16)	0.0024
<i>C. Time spent in major locations, youths 11–17</i>			
	<i>n</i> =231	<i>n</i> =671	
Indoor at home	67.01 (±2.25)	61.02 (±1.52)	<0.0001
Outdoor at home	1.48 (±0.50)	2.31 (±0.42)	0.0352
School/Public building	12.12 (±1.86)	14.03 (±1.14)	0.0954
Indoor — other	6.12 (±1.67)	9.69 (±1.22)	0.0026
Bar/Restaurant	0.87 (±0.46)	0.93 (±0.23)	0.7959
Outdoor — other	8.00 (±1.65)	5.45 (±0.67)	0.0009
In vehicles	3.08 (±0.49)	4.87 (±0.49)	<0.0001
Near vehicles — outside	0.00 (±0.01)	0.14 (±0.09)	0.0840
Office/Factory	0.22 (±0.35)	0.18 (±0.14)	0.8096
Mall/Store	1.10 (±0.44)	1.37 (±0.30)	0.3795
<i>D. Time spent in major locations, children <11</i>			
	<i>n</i> =324	<i>n</i> =1126	
Indoor at home	72.33 (±2.38)	70.52 (±1.17)	0.1521
Outdoor at home	2.69 (±0.66)	4.07 (±0.45)	0.0025
School/Public building	5.72 (±1.21)	7.83 (±0.75)	0.0066
Indoors — other	8.74 (±1.85)	8.15 (±0.91)	0.5533
Bar/Restaurant	0.66 (±0.20)	0.47 (±0.09)	0.0564
Outdoors	4.25 (±1.00)	4.17 (±0.54)	0.8950
In vehicles	3.66 (±0.53)	3.57 (±0.31)	0.7805
Near vehicles — outside	0.01 (±0.01)	0.05 (±0.03)	0.1481
Office/Factory	0.07 (±0.08)	0.12 (±0.09)	0.5973
Mall/Store	1.86 (±0.47)	1.05 (±0.18)	0.0001

Table 4. Percent time spent in major locations (with 95% CI), all respondents, comparison between two major urban centres.

Location	Toronto, ON (n=353)	Chicago, IL (n=79)	P
Indoor at home	67.21 (± 2.13)	67.19 (± 4.97)	0.9954
Outdoor at home	1.01 (± 0.36)	1.30 (± 0.85)	0.6531
School/Public building	2.98 (± 0.84)	1.55 (± 1.15)	0.3199
Indoors — other	7.38 (± 1.46)	11.83 (± 3.82)	0.0890
Bar/Restaurant	2.11 (± 0.65)	1.62 (± 0.74)	0.6589
Outdoors — other	4.48 (± 1.01)	5.18 (± 3.74)	0.7128
In vehicles	4.72 (± 0.47)	4.52 (± 1.08)	0.8150
Near vehicles — outside	0.03 (± 0.03)	0.08 (± 0.20)	0.4172
Office/Factory	7.39 (± 1.46)	5.74 (± 3.00)	0.5192
Mall/Store	2.69 (± 0.64)	1.00 (± 0.59)	0.1200

Education was the proxy for socioeconomic status and, with the proviso that 20–25% of respondents declined to answer this question, education levels were similar with somewhat more NHAPS respondents having completed college and at least some postgraduate education. Similarly, about 5% more of NHAPS respondents reported full-time employment than CHAPS respondents. Rates of current smoking among adult respondents were within 1% in the two studies.

In Table 3, the 10 major locations identified in the NHAPS publications are compared to the CHAPS results. All results are within 2%, or 28 min, in the 10 major groups. When youth and children are selected out for comparison the differences are greater but the samples are small and variability higher. One of the greatest differences seen is in Canadian youth who spend significantly more time indoors at home than U.S. youth (Table 3C). That difference is not seen in the children under 11 years of age (Table 3D).

Table 5. Mean time in minutes (± 1 SEM) per 24-h day spent in six major locations: winter vs. summer^a comparisons in three age groups.

Location	Winter		Summer	
	Canada	USA	Canada	USA
A. Adults				
	n=503	n=1883	n=535	n=1983
Indoor at home	999 (± 13)	971 (± 7)	837 (± 13)	898 (± 7)*
Work/School	124 (± 9)	145 (± 5)	145 (± 9)	125 (± 5)
Indoors/Other	175 (± 10)	150 (± 5)	193 (± 11)	156 (± 5)*
Bar/Restaurant	32 (± 4)	34 (± 2)	22 (± 3)	32 (± 2)*
Outdoors	33 (± 4)	58 (± 4)*	148 (± 9)	135 (± 4)
In vehicles	77 (± 4)	83 (± 2)	94 (± 6)	93 (± 2)
B. Age 11–17				
	n=62	n=166	n=78	n=187
Indoors at home	1004 (± 25)	893 (± 22)*	979 (± 37)	906 (± 24)
Work/School	236 (± 27)	229 (± 18)	34 (± 13)	85 (± 12)*
Indoors/Other	102 (± 19)	187 (± 21)*	144 (± 28)	190 (± 18)
Bar/Restaurant	17 (± 9)	15 (± 4)	10 (± 5)	14 (± 3)
Outdoors	35 (± 8)	60 (± 7)	233 (± 30)	175 (± 14)
In vehicles	46 (± 6)	56 (± 5)	41 (± 5)	70 (± 8)*
C. Children: age < 11 years				
	n=88	n=275	n=112	n=333
Indoors at home	1137 (± 28)	1067 (± 19)	931 (± 35)	989 (± 16)
Work/School	87 (± 18)	126 (± 12)	40 (± 11)	48 (± 8)
Indoors/Other	119 (± 22)	153 (± 16)	208 (± 31)	141 (± 12)
Bar/Restaurant	16 (± 4)	7 (± 1)	9 (± 2)	9 (± 1)
Outdoors	43 (± 9)	34 (± 4)	194 (± 19)	203 (± 12)
In vehicles	37 (± 4)	53 (± 4)*	58 (± 8)	51 (± 4)

^aCalendar definition of winter and summer.

* $P < 0.01$.

** $P < 0.001$.

*** $P < 0.0001$.

From the air pollution exposure assessment viewpoint the time outdoors would be considered important and the overall results show that NHAPS respondents spent 6.92% time of a 24-h day outdoors (outdoor at home+outdoors/other+near vehicles/other) and CHAPS respondents spent 6.05% time out of doors. This is again less than a 1% difference. This difference was principally made up by more time indoors at home by Canadians.

NHAPS respondents also reported more time in vehicle (5.74%) than their CHAPS counterparts (5.33%). The vehicle was principally the automobile in both surveys.

Table 4 compares the two large urban centers of similar geographic location, Toronto, Ontario and Chicago, Illinois. "All respondents" numbers are small but results are very similar.

The only analysis in which the comparison is not so highly similar is when the results are broken down by season to look at winter and summer specifically as the seasons most likely to differ (Table 5, A-C). Looking at time in average minutes spent in the 10 major locations Canadians spend less time outdoors in winter (youth, adults), and Americans more time indoors in summer (adults). This seasonal effect may explain the overall youth indoors time differences seen in Table 3C.

Discussion

The similarity of overall response rates suggests that the sampling frame methodology itself was "transportable" throughout Canada and the U.S. The available age, sex and sociodemographic data as well as smoking habits of respondents in the two studies are comparable, suggesting the same sorts of people are being sampled. For developing mathematical models of large populations to ambient air pollutants, for example, potential exposures in the two studies are very similar and would suggest that either data set or a combined data set could be used. Among the 10 U.S. data bases Johnson et al. (1992) compared, the California vs. Valdez, Alaska, comparison is perhaps most similar to this analysis. In the six major location groups he found that for children under 12 years of age, the mean difference in number of minutes per person was within 2 min/person-hour between these two geographic areas. Comparing adults in Denver and Washington, the difference between means was less than 0.8 min/person-hour in the six major locations. Johnson has also shown that differences in time/activity studies within the USA often relate to methodology, such as whether retrospective or real-time periods were used. Here, when identical methodology has been used, the NHAPS and CHAPS data are remarkably similar and at times virtually interchangeable.

When season-specific pollutants are considered (i.e., ozone which also has an indoor/outdoor gradient) Canadian

and American data may need to be examined separately because seasonal exposures may be different. For example, in summer when ozone levels peak in Canada (Liu et al., 1995), Canadians are spending more time outdoors and may therefore have more exposure at a given ambient ozone level. Johnson et al. (1992) also showed a small effect of season in stepwise regression analyses as a "relatively good" predictor of time-activity patterns along with sleeping, work and student status.

Nevertheless, the overall result in this analysis is that the two populations are sufficiently similar to the larger NHAPS, or a merged NHAPS and CHAPS data set, to predict Canadian, or North American population exposures. It appears that lifestyles, work hours, and cultural habits drive time-activity patterns to a much greater extent than any effect of geography except, perhaps, the effect of seasons.

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